GEOLOGY OF THE MANTI AREA, CENTRAL UTAH

A Thesis Presented for the Degree
of Bachelor of Science

By

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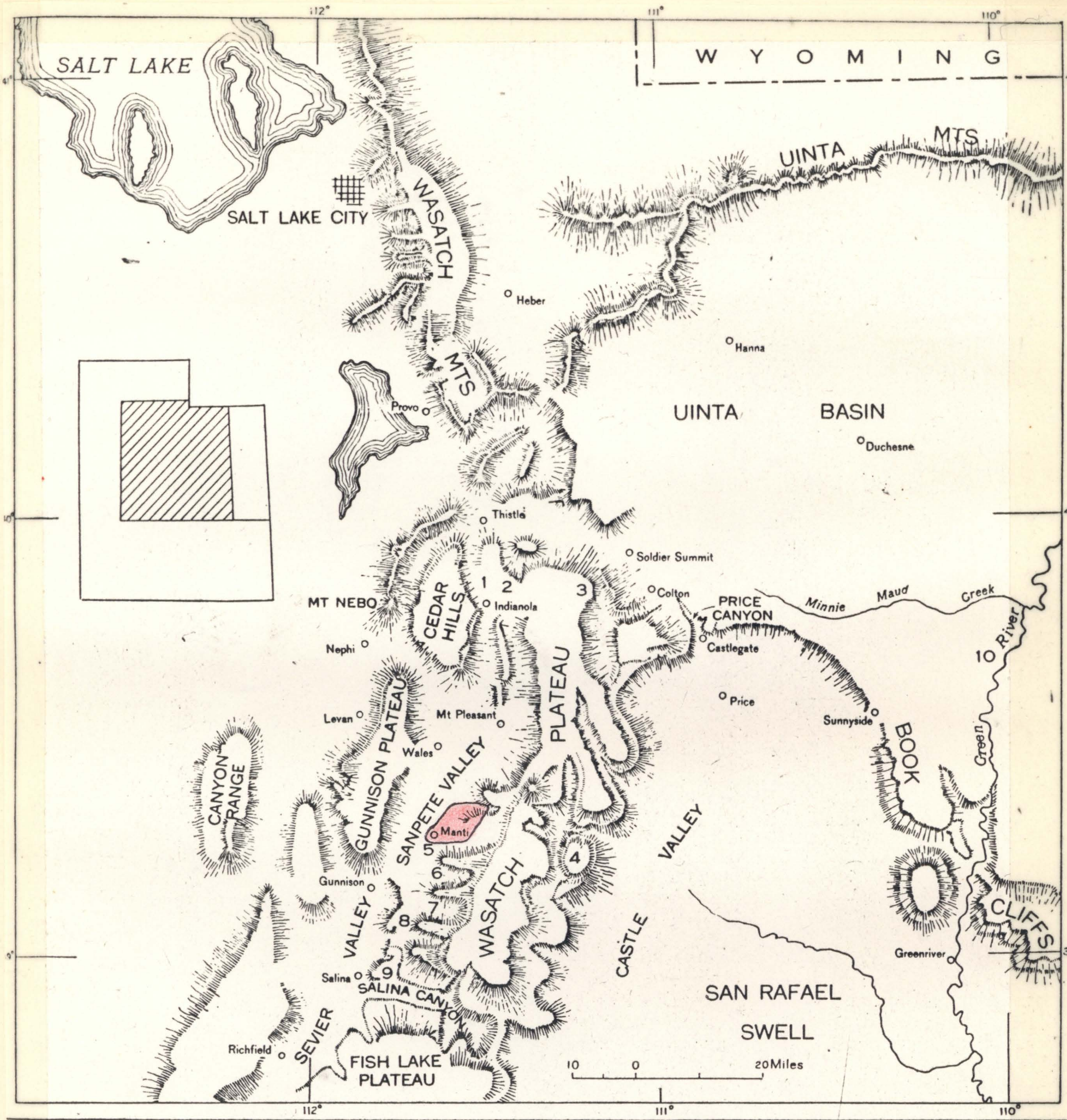

FIGURE ■.—Index map of part of Utah, showing the localities discussed in this report.

Dry Creek and Hjork Creek.
Little Clear Creek.
Bennion Creek.
North Horn Mountain.
5. Allen Valley.
6. Sixmile Canyon.
7. Twelvemile Canyon.
8. Arapien Valley.
9. Twist Gulch.
10. Mouth of Desolation Canyon on Green River.

Figure 1.---Index map of Utah showing the area of study (Spieker, 1946, p. 119).

INTRODUCTION

Scope

The Manti area includes approximately 30 square miles. The town of Manti lies in the southwest corner of the area. The area is bounded on the north by the north wall of Willow Creek Canyon, on the east by 111° 30' W. longitude, on the south by the drainage divide between Manti Canyon and Six Mile Canyon and on the west by U.S. Highway 89. (Figure 1 and the geologic map.) The area includes part of Sanpete Valley and the western edge of the Wasatch Plateau.

Purpose

The purpose of the field work was to produce a geologic map of the Manti area and to collect data with which to write a geologic report to be submitted as partial fulfillment of a Bachelor of Science degree.

Acknowledgements

The field work was carried out by the writer and by John R. Connolly during eight weeks between June and August of the summer of 1967. The mapping was carried out by plane table and alidade and by the use of the U.S. Department of Agriculture Soil Conservation Service aerial photographs.

Professors who assisted with the field work are Dr. M.P. Weiss, Ohio State University, Dr. Richard Threet, San Diego State University, Dr. James Collinson, Ohio State University, Dr. Charles Shultz, Ohio State University, and Dr.

Eugene Szmuc, Kent State University.

Description of Area

Manti, which is the only town in the area, has a population of approximately 2,500 people. Manti, like most of the other small towns in Sanpete Valley, was first settled by Mormons who established their communities at the heads of the major canyons with flowing streams. Most of the inhabitants depend upon farming or ranching for a livelihood. The farming in the valley is general farming and it depends heavily upon irrigation water from the Wasatch Plateau. The animals raised on the ranches are cattle, sheep and turkeys. In recent years, turkeys have become the most profitable product of the valley.

Accessibility

The only major highway in the area is U.S. Highway 89 which runs through the town of Manti. Manti Canyon road runs east from Manti to the top of the Wasatch Plateau. It is a dirt road and can be easily traveled by truck. Parts of the plateau can only be traveled by jeep, horseback or on foot.

Manti is serviced by daily railroad and bus transportation. A small airport lies north of the town, which is owned by both Manti and Ephraim. No commercial air service is available, however, and the airport is limited to light aircraft.

STRATIGRAPHY

North Horn Formation

Definition.--The North Horn formation was defined by E.M. Spieker (1946, p. 132) as the lower member of the Wasatch formation as identified in the Wasatch Plateau. The type locality of the formation is on North Horn Mountain. The basal conglomerate which used to be a part of the lower Wasatch was placed in the Price River formation.

At the type locality the formation is divided into four general units. The lower unit is 850 feet thick and is composed mostly of grey and variegated shales. There also is sandstone and conglomerate to a lesser degree and a minor amount of limestone. The next unit is 250 feet thick and is made up of grey shale, buff to light cream sandstone and some limestone. The third unit is similar to the first. It consists of 300 feet of grey to variegated shale and thin beds of buff colored sandstone. The highest unit is composed of red to variegated shales interbedded with buff sandstone and a small amount of limestone. This unit is 250 feet thick.

Description.--In the Manti area the North Horn formation is exposed from the mouth of Manti Canyon eastward to beyond the area boundary on the north wall of Manti Canyon. At the mouth of Manti Canyon the monocline flattens out and very little North Horn is exposed. The monocline rises to the northeast and the exposure of the North Horn formation increases to more than 1200 feet. The dip of the beds increases as you get higher in the exposed section. In the area where the formation was measured and approximately 1/3 of the way up in the section the strike of the beds is N 36° E and the dip is 7° W. At the North Horn-Flagstaff contact, the strike of the North Horn formation is N 40° E and the dip is 33° W. In the Manti area the North Horn formation intertongues and intergrades with the Flagstaff limestone above. The Price River formation below, is nowhere present in the Manti area. The intergradational relationship between the North Horn formation and the Flagstaff limestone does not exist throughout the region. There are local unconformities between the North Horn and the Flagstaff in the Six Mile Canyon Area and in the southern part of the Gunnison Plateau.

In the Manti area the North Horn formation is made up of a sequence of fresh water mudstone, sandstone, and limestone. The lowest exposure lies within the lowest of the four gross units into which Spieker divides the North Horn formation (Spieker, 1946).

The mudstones are grey to variegated in color. They are characteristically hard, crumbly, calcareous, and slope-forming. The sandstone is light grey, becoming more yellow toward the top of the formation. The grain size tends to get smaller and the bedding thinner going up in the section. All the sandstones are calcareous and cliff-forming. The conglomerates are found within the lower third of the measured section. The beds are lenticular and up to five feet thick. They often disappear laterally within 100 feet. They are calcareous and cliff forming.

Measured Section.--The section of the North Horn formation was measured in Manti Canyon. The measurement began at the road at the base of the north wall of the canyon and approximately 1.5 miles east of the entrance to the Manti-La Sal National Forest.

The starting point was located at a fork in the road 1/2 mile east of a small power station on the south side of the road. The section was measured in a direction of N 30° E. The section was measured using the Hewett method. The North Horn-Flagstaff contact, which is gradational was chosen where redbeds started to interbed with cliff-forming limestone.

North Horn formation:	Feet
1. Covered interval..................................	177
2. Interbedded mudstone and sandstone, 10:1.......	
Sandstone, N8 light gray on fresh surface, weathers to 10R 5/4 pale reddish brown, coarse grained, angular to sub-angular, quartz, specks of pink and black chert, calcareous, massive bedding, cliff-forming, friable, beds 4-5 feet thick..................................	
Mudstone, 10R 5/4 pale reddish brown, weathers to 5R 4/2 grayish red, dry, hard, crumbly, calcareous, forms slopes.......................	93
3. Conglomerate and sandstone and mudstone........	
Sandstone, similar to sandstone of unit 2, less chert......................................	
Conglomerate, lenses within the sandstone, largest pebbles are approximately 1 inch in diameter, average size is 1/4 to 1/2 inch, mostly quartz, calcareous, beds up to 5 feet thick, pebbles are well rounded, sub-spheroidal, limited to basal part of unit.................	
Mudstone, similar to mudstone in unit 2, interbedded with sandstone in upper 2/3 of unit.....	410

		Feet
4.	Interbedded limestone, sandstone, mudstone, 1:3:10..	
	Limestone, 5Y 7/2 yellow grey, fine grained, globular, massive, verticle joints, cliff-forming..	
	Sandstone, N8 light grey, medium grained, sub-angular, quartz, calcareous cement, cliff-forming, friable................................	
	Mudstone, 10R 5/4 pale reddish brown, hard, crumbly, very calcareous.......................	205
5.	Interbedded Sandstone and Mudstone 1:5.........	
	Sandstone, 5Y 6/4 dusky yellow, fine grained, massive, very slightly calcareous, hard, cliff-forming, beds 2-6 feet thick...................	
	Mudstone, 10R 5/4 pale reddish brown, weathers to 5YR 5/6 light brown, crumbly, calcareous....	325
	Total North Horn formation exposed.............	1210

Distribution and Thickness.--The four units of the North Horn formation which are distinguished at North Horn Mountain can be traced over a 600 square mile area, the center of which is east of Manti (Spieker, 1946). From this point the formation thickens to the north and east. A maximum thickness of 2,200 to 2,500 feet is present between Castlegate and Soldier Summit. The formation thins to the west and a minimum thickness of 500 feet is present on Salina Creek. The section measured in Manti Canyon was 1210 feet thick.

Fossils-Age-Correlation.--No fossils were collected from the North Horn formation in the Manti area. Abundant fossils have been collected in several localities from this formation in the past, however. The fossils are both invertebrate, fresh-water mollusks and vertebrates. Genuses of fresh-water mollusks found are, Unio, Bulinus, Columna, Goniobasis, and Viviparous. Vertebrate fossils found represent the groups Ceratopsia, Chelonia, and Crocodilia. The vertebrate fossils have been found most dominantly on the southwest ridge of North Horn Mountain, which is the type area for the formation. One collecting location was in Manti Canyon on the northwest slope. The lower part of the North Horn formation contains fossils which have definitely been identified as Cretaceous in age. The upper part has yielded mammalian bones which have been recognized as Paleocene in age. Therefore the Cretaceous-Tertiary boundary lies within the North Horn formation without a break in the succession of beds. Based on this information, the North Horn formation has been correlated with some part of the Lance and Fort Union formations of the northern plains (Spieker, 1946).

Origin.--The North Horn formation displays changes of facies over short distances, with many units changing thickness and in many places tonguing out completely. This is especially pronounced in the lowest of the four major divisions made by Spieker (1946) and the third from the bottom. While this formation was being deposited the depositional conditions altered between lacustrine and fluvatile. In the Manti area the lowest 500 feet of North Horn is predominantly fluvatile in origin. The dominant lithology here is coarse-grained sandstones and conglomerates. Many of the beds are lenticular in shape. The mudstone and limestone beds are fine-grained and evenly bedded and are more typical of a lacustrine origin.

Flagstaff Limestone

Definition.--The Flagstaff limestone was defined by Spieker (1946, p. 135) as those beds previously known as the Flagstaff limestone member of the Wasatch formation. The formation consists mostly of fresh-water limestone but small amounts of sandstone, gypsum, oil shale, and volcanic ash occur. West of the Wasatch Plateau the formation contains some minor amounts of coal and toward the southwest the limestone is extensively silicified.

Description.--In the Manti area the Flagstaff formation forms the dip slope on the outer flank of the Wasatch monocline. The dip slope is covered by mass wasting and vegetation and no good outcrops of Flagstaff occur on it. The formation is well exposed on the north wall of Manti Canyon and the north and south walls of Willow Creek. The formation grows in thickness from west to east in Manti Canyon. The attitude of the Flagstaff formation in Manti Canyon is approximately strike N 35° E and dip 33° W, near the top. On the south side of Willow Creek the formation strikes N 35° E and dips 26° W, and on the north side of Willow Creek the strike is N 40° E and the dip is 27° W. The Flagstaff formation intergrades with the North Horn formation below and the Colton formation above.

The Flagstaff formation in the Manti area is composed of fresh-water sediments. The dominant lithology is limestone and it is interbedded with shale, mudstone and a small amount of sandstone.

The limestone in the lower half of the measured section is yellowish grey, very fine-grained and nearly lithologic, vuggy and fossiliferous in certain horizons. As you get higher in the formation the limestone becomes light gray in color, chert occurs more frequently and some beds are dolomitic. All the limestone beds are cliff-forming and the thicker units are very conspicuous. The shale is grey, calcareous, and slope forming. The sandstone was yellowish-gray in color, calcareous, and very friable. There was only a total of approximately 15 feet of sandstone in the entire formation where the formation was measured.

The thinbedded, platy, and oolitic limestone characteristic of the Green River formation is lacking in the Flagstaff limestone and can be used to distinguish between them.

Measured Section.--The Flagstaff limestone was measured on the north wall of Willow Creek canyon. The starting point was 3 miles east of U.S. Highway 89 and approximately 300 yards north of Willow Creek, where the lowest limestone outcrops occur. The section was measured in a direction of N 50° W, by using a 50 foot steel tape and the Hewett method. The contact between the Flagstaff limestone and the Colton formation was made where the lowest variegated shales were encountered.

Flagstaff Limestone	Feet
1. Limestone, 5Y 7/2 yellowish gray, fine-grained, sub-lithographic, regular bedding, joints perpendicular to beds, average 2-4 feet thick, cliff-forming, vuggy with calcite coatings on vug surfaces, fossiliferous, sharp contacts with beds above and below, ratio of ls.:sh. is 1:2, fossiliferous, fossil hash and *Lioplacodes*, and *Goniobasis*...	

		Feet
	Shale, 5YR - N 5.5 medium light gray, blocky when fractured, medium hard, very calcareous, massive beds, 2-3 feet thick, forms 35° slope, sharp contacts, little variation in thickness........................	200
2.	Limestone, alternating medium light grey N 6 1/2 and yellowish gray 5Y 7/2, vuggy, fine-grained, regular bedding, joints perpendicular to beds, beds approx. 4 feet thick, cliff-forming, non-fossiliferous, sharp contacts, at 4 feet and 23 feet from bottom there is a 6 inch layer of light grey ls. with pellicular algae................	82
3.	Interbedded limestone and mudstone, 1:2.......	
	Limestone, 5Y 7/2 yellowish gray, fine-grained, massive, cliff-forming, vuggy, similar to ls. of unit 1.	
	Mudstone, N 6 medium light grey, blocky, slightly calcareous, beds 2-4 feet thick......	74
4.	Limestone, N 7 light grey, fine-grained, beds are 2-10 feet thick, cliff forming, less vuggy than unit 1, 18 feet from bottom there is a 3 foot thick darker grey bed of trowertine texture, fossiliferous, Physa collected..............................	36
5.	Interbedded shale and sandstone, 3:1..........	
	Sandstone, 5Y 7/2 yellowish gray, texture of a grit, massively bedded, joints perpendicular to bedding, very friable, very calcareous.....	
	Shale, N 6 medium light gray, calcareous, interbedded with thin limestone beds, cliff-forming......................................	53
6.	Interbedded limestone and sandstone...........	
	Limestone, 5Y 7/2 yellowish gray, fine-grained, cliff-forming, vuggy, un-fossiliferous, similar to unit 5 without interbedded shale..	
	Sandstone, brown, coarse-grained, angular, quartz, cliff-forming, begins 15' from bottom of unit, calcareous cement, weathers differentially....................................	39

		Feet
7.	Limestone, N 5 medium gray, weathers yellowish, fine-grained, cliff-forming, thin bedded, wavy..............................	46.5
8.	Limestone, 5 Y 6/1 light olive gray, fine-grained, dolomitic, locally cherty, thinly bedded, blocky, joints perpendicular to bedding, a 3 foot brecciated chert bed near top of unit...................................	72
9.	Shale and Limestone, 10:1, no outcrops........	110
10.	Shale, no outcrops, light gray, gradual slope..	115
11.	Limestone and Shale, 1:10, no outcrops, greyish.......................................	310
	Total Flagstaff limestone exposed.............	1137.5

Distribution and Thickness.--The Flagstaff limestone is one of the most prominent and extensive formations in central Utah. It forms the dip slope of the Wasatch monocline to as far south as Sixmile Canyon where the Green River formation forms the most westerly hogbacks. It caps the top of the Wasatch Plateau and the escarpment on the east side of the Gunnison Plateau. It is also found in the Valley Mountains, the Long Ridge and the Pavant Range. The thickest sections are in the southern part of the Wasatch Plateau but it appears to be absent from the high plateaus south of the Wasatch. In the Wasatch Plateau the thickness varies between 200 and 1500 feet, with an average of 800 to 1000 feet (Spieker, 1946). The section measured in Willow Creek canyon was 1137 feet thick.

Fossils and Age.--Parts of the Flagstaff limestone contain abundant fresh-water pelecypods and gastropods. In the Manti area the genuses *Lioplacodes* and *Goniobasis* were found in unit 1 and *Physa* was found in unit 4. On the basis of the fresh-water mollusks collected in the past, Spieker (1949) feels the Flagstaff limestone is definitely Paleocene in age. It is felt that since the Flagstaff limestone has a conformable boundary with the underlying Paleocene North Horn formation that there was no great time lapse between the two and that the Flagstaff could well be upper Paleocene.

Origin.--The fresh-water lake into which the North Horn formation was deposited continued to exist and the Flagstaff formation was deposited in the lake conformably with the underlying North Horn formation. The shoreline must have been farther away from this area in the late Paleocene, because the lenticular coarse grained channel deposits typical of the North Horn formation are absent from the Flagstaff limestone. The shoreline could not have been more than a few miles away during a portion of the period of deposition because an unconformity exists between the North Horn formation and the Flagstaff limestone just to the south in the Sixmile Canyon area. In units 5 and 6 of the Flagstaff limestone there is a total of approximately 35 feet of coarse-grained sandstone. These beds may have been deposited during the exposure of the Sixmile Canyon area. The fact that there are no conglomerates present, which have been observed in the Flagstaff limestone in some areas (Spieker, 1949), indicates this area was far from the lake shore during most of its deposition.

Colton Formation

Definition.--The Colton formation was officially defined by Spieker in 1946 as the upper member of the Wasatch formation. The type section is in the hills north of Colton and consists of the beds between the Flagstaff limestone below and the Green River formation above. In the type section the formation consists of three types of sediments: gray salt and pepper and greenish-buff sandstone, siltstone that weathers golden brown, and shale that varies in color from gray to red to variegated. There are three other formations in the Wasatch Plateau which contain variegated beds. These formations, which are all older than the Colton formation are the Morrison formation, parts of the Indianola group, and the North Horn formation. Generally these beds can be distinguished by their lithology and only present a problem where the structural relationships are complex. In the Manti area, the North Horn formation and the Colton formation are easily distinguished by the prevelance of green beds in the Colton formation and their absence in the North Horn formation.

Description.--In the Manti area, the Colton formation is exposed on the north side of the mouth of Manti Canyon, the north and south sides of the mouth of Willow Creek and on the front of the monocline between these two valleys where it is not covered by rockslide debris. The base of the Colton formation is almost entirely covered by float and rockslide material from the Flagstaff formation which it conformably overlies. The Colton Green River contact is also conformable. This boundary, which runs along the front of the monocline, is covered to a large extent by alluvium.

The Colton formation in the Manti area consists of variegated mudstones and shales, sandstone and limestone. The mudstones and shales range in color from olive-green to brown to reddish. They all tend to be calcareous. The limestone beds are thin, usually fine-grained and are dolomitic near the base of the formation. They are various shades of grey in color and several of the beds contained fossils. The sandstone beds are fine to medium-grained and are often cross-bedded and lenticular in shape.

Measured Section.--The Colton formation section was measured on the front of the Wasatch Monocline due east of Temple Hill and northeast of Manti. The Flagstaff-Colton boundary, which is gradational, was chosen where the lowest red beds in the Colton formation were exposed. The boundary may be lower but due to much Flagstaff float it cannot be seen. The formation was measured by using a 50 foot steel tape and the Hewett method. The traverse was made in a direction of N 56° W. The beds at the contact had a strike of N 34° E and dipped 34° to the west. The Colton-Green River contact, which is also gradational, was chosen where there were no further red beds and the limestone beds became fine-grained and chalky.

Colton formation	Feet	Inches
1. Red and Green Mudstones and Limestone...		
Red mudstone, 10R 4/2 grayish red, blocky, calcareous......................	5	6

		Feet	Inches
	Green mudstone, 10Y 4/2 grayish olive, blocky, calcareous........................	5	0
	Dolomitic limestone, 5Y 8/1 yellowish gray, fine-grained, pinhole sized vugs, cliff-forming..........................	2	0
	Green mudstone, 10Y 4/2 grayish olive, calcareous...............................	17	9
	Colomitic limestone, 5Y 8/1 yellowish gray, fine-grained, cliff-forming.......	6	0
2.	Mudstone and limestone..................		
	Mudstone, 10Y 6/2 pale olive, calcareous, breaks into pellicular pieces...........	10	6
	Limestone, 10YR 7/4 greyish orange, very fossiliferous, elliptio and goniabasis identified................................	2	0
	Mudstone, 10Y 6/2 pale olive, calcareous.................................	31	6
3.	Sandstone and Mudstone..................		
	Sandstone, 10YR 8/6 pale yellowish orange, fine-grained, coarser grains of clear quartz sprinkled through it, cliff-forming, calcareous...............	3	0
	Mudstone, 10Y 6/2 pale olive, calcareous.................................	23	0
4.	Limestone and mudstone..................		
	Limestone, 10YR 7/4 greyish orange, fossiliferous, goniabasis, elliptio and physa identified, poorly bedded, jointed, cliff-forming..................	4	0
	Mudstone, 5YR 4/4, moderate brown, calcareous, breaks into pellicular pieces.................................	21	0
	Mudstone, 5Y 3/2 olive gray, calcareous.................................	21	0
	Mudstone, 5YR 4/4 moderate brown, calcareous..............................	27	3

	Feet	Inches
Limestone, 10YR 7/4 greyish orange, fossiliferous, viviparous identified, well bedded, cliff-forming, fetid.......	5	0
Mudstone, 5YR 4/4 moderate brown, calcareous................................	20	0
5. Limestone and shale......................		
Limestone, 5Y 7/2 yellowish grey, fine-grained, bedded, cliff-forming..........	2	0
Shale, 5GY 5/2, dusky yellow green, slabby, calcareous......................	7	3
Limestone, 5Y 7/2 yellowish grey, fine-grained, cliff-forming..................	4	0
Shale, 5GY 5/2, dusky yellow green, calcareous, covered by limestone float..	52	6
Limestone, 5Y 6/1 light olive grey, thin-bedded, cliff-forming, cross-bedded appearance........................	2	0
Shale, 5GY 5/2 dusky yellow green, calcareous..............................	16	9
Limestone, 5Y 6/1 light olive grey, fine-grained............................	2	0
Shale, 5GY 5/2 dusky yellow green, calcareous..............................	34	6
Limestone, 5Y 6/1 light olive grey, fine-grained............................	1	0
Shale, 5GY 5/2 dusky yellow green, calcareous, mostly covered by limestone float............................	89	3
6. Sandstone and Shale.....................		
Sandstone, 5Y 7/2 yellowish gray, medium to fine-grained, very friable, calcareous, massive, cliff-forming, stained red from adjacent shale.........	6	0
Shale, red, calcareous..................	4	0
Sandstone, 5Y 7/2 yellowish gray, medium grained, contains grains of pink, black, and clear quartz, slightly cross-bedded, lenticular bed...........................	0-10	3

		Feet	Inches
	Shale, 5YR 6/4 light brown, highly weathered................................	42	0
7.	Mudstones..............................		
	Mudstone, 5Y 6/1 light olive gray, very hard, very calcareous, slightly cliff-forming................................	2	0
	Mudstone, 5YR 5/2 pale brown, calcareous................................	47	3
	Mudstone, 5GY 6/1 greenish gray, slightly calcareous......................	5	3
8.	Sandstone and mudstone..................		
	Sandstone, 5Y 7/2 yellowish, medium-grained, thin-bedded, cliff-forming.....	8	3
	Mudstone, 10YR 4/2 dark yellowish brown, calcareous.......................	63	0
	Mudstone, 5Y 4/1 olive gray, weathers to 5GY 6/1 greenish gray, calcareous....	21	0
9.	Limestone, sandstone and mudstone.......		
	Limestone, 5Y 8/1 yellowish gray, fine-grained, very fractured, crumbly appearance, cliff-forming.....................	3	0
	Mudstone, 10YR 4/2 dark yellowish brown, calcareous.......................	47	7
	Sandstone, 5Y 7/2 yellowish, medium-grained, moderately friable, cliff-forming................................	2	0
	Mudstone, 10YR 4/2 dark yellowish brown, calcareous.......................	15	9
	Limestone, 5Y 8/1 yellowish gray, fine-grained, highly fractured, cliff-forming................................	5	3
	Mudstone, 5YR 4/4 moderate brown, calcareous................................	47	3
10.	Sandstone and mudstone..................		
	Sandstone, 5YR 6/4 light brown, fine-grained, small scale cross-bedding, cliff-forming............................	4	0

		Feet	Inches
	Mudstone, 5YR 4/4 moderate brown........	12	6
	Sandstone, 5Y 7/2 yellowish gray, medium-grained, angular, thin-bedded, friable, cross-bedded, cliff-forming, lenticular..............................	0-18	5
	Mudstone, 5YR 4/4 moderate brown........	73	6
11.	Limestone, mudstone and sandstone.......		
	Limestone, chlorellopsis, algae is 10YR 6/2 pale yellowish brown, matrix is 5GY 8/1 light greenish gray, very hard, massive, cliff-forming............	3	0
	Mudstone, 5YR 4/4 moderate brown........	42	0
	Sandstone, 5Y 7/2 yellowish gray, medium-grained, angular, friable, cliff-forming...........................	3	0
	Mudstone, 5YR 4/4 moderate brown........	68	3
	Total Colton formation exposed..........	970	3

Distribution and Thickness.--East of the type area, the Colton formation is exstensively exposed and reaches a thickness of 1600 feet in the Tavaputs Plateau. Over most of the Wasatch Plateau the formation is missing completely. On the west side of the plateau the Colton is exposed along the base of the Wasatch monocline in several places between Mount Pleasant and Salina. West of the type area the Colton formation grades into the Green River formation. The Colton section measured in the Manti area was 970 feet thick, and the formation thickened toward the northeast from this area, so the maximum thickness in the Manti area is not known.

Fossils.--To date the only fossils found in the Colton formation have been freshwater mollusks. The fossils have had no value in proving or disproving a Wasatch age for the

Colton formation. No vertebrate fossil evidence has ever been found in the Colton formation. In the limestone beds of unit 2 the gastropod Goniobasis and the pelecypod Elliptio were found. In the lower limestone bed in unit 4, the gastropod Physa was found in addition to Goniobasis and Elliptio. In the higher limestone bed of unit 4, the gastropod Viviparous was identified. The limestone in unit 11 contained Chlorellopsis algal.

Origin.--The Colton formation has gradational boundaries with the Flagstaff limestone below and the Green River formation above. The depositional environment is similar for all of these formations. The sandstones are channel deposits. Most of them show cross bedding and they are lenticular in shape. The shales and mudstones are floodplain and lake deposits. The limestones were deposited in the temporal, Early Eocene, freshwater Green River Lake. Long periods of lacustrine and floodplain deposits alternate with short periods of sandstone channel deposits. The frequency of the channel deposits increases toward the top of the formation. The green color in some of the shales and mudstones is possibly from disseminated glanconite which was produced by the reduction of iron oxide derived from older formations adjacent to the zone of deposition. Iron oxide which was not reduced could be the source of the red hues in the shales and mudstones.

Correlation and Age.--The Colton formation is considered to be early Eocene based on structural relationships. The fresh water fauna found give no indication of its exact age, and no vertebrate remains have yet been discovered to indicate an age other than early Eocene.

Green River Formation

Definition.--The Green River formation was named by F.V. Hayden (1869, p. 89) from outcrops studied in western Colorado, southwest Wyoming and eastern Utah. The Green River formation has been divided into two members. The lower member is made up 100 to 400 feet of blue-gray to light blue shale, some of which is oil shale. The upper member is approximately the same thickness as the lower member, but is composed of cream to tan limestones and contains little or no oil shale. The limestone member is locally oolitic. This member also contains one to four beds of volcanic tuff, which serve as excellent marker beds especially in the vicinity of San Pete Valley. There is an erosional break at the top of the Green River formation which is regional in extent. Until this break, the beds are continuous, except for local unconformities, from the base of the Price River formation.

Description.--In the Manti area the Green River formation is exposed at Temple Hill and in an area 2 miles N-NE of Manti between U.S. Route 89 and the western base of the Wasatch monocline. At Temple Hill, there is upper Green River formation thrust over upper Green River formation. The Green River formation beneath the thrust is relatively flat lying. It has a strike of N 85° W and a dip of 5° E. The thrust sheet of Green River formation is synclinal in nature. The axis of the syncline trends approximately N-S. The west flank of the syncline has a strike of N 13° W and a dip of 12° E. The strike of the east flank of the syncline is N 38° E and the dip is 11° W. The exposure of the Green River formation N-NE of Temple Hill is flat lying. In San Pete Valley the Green River formation has been thrust over the Arapien shale and is overlain by a thrust sheet of the Crazy Hollow formation. In the Wasatch Plateau the Green River formation is conformably underlain by the Colton formation.

In the Manti area the Green River formation is made up of a sequence of freshwater limestone and shale, all of which lies within the upper member of the formation. The limestone is pinkish-grey to greyish-yellow. It is argillaceous, becoming less so toward the top of the unit, thin-bedded, platy and vuggy in the lower one fourth of the unit. The limestone characteristically breaks into thin slabs, generally less than one inch thick, and two to three feet long. The top bed of limestone contains abundant pebbles of opal which are stained orange in color. Just below the top limestone bed is a four foot thick layer of volcanic tuff. The tuff is very micaceous. The mica is biotite and the flakes have their basal cleavage oriented parallel to the bedding plane. The tuff is quite prominent and serves as a good marker bed in correlating the Green River formation.

The shale in the Green River formation is grey in color and very calcareous. In the area where the section was measured there were no good exposures of the shale. The shale is slope-forming and the beds are covered by shale float.

<u>Measured Section</u>.--The section of the Green River formation was measured on the east side of temple on a line nearly directly east of the temple. The section measured extends

from the dirt road which encircles Temple Hill to the top of the hill. The point where the measurement begins is not the base of the section. There is a covered interval between the top of the Colton formation and the lowest exposure of the Green River formation. The thickness of the covered Green River formation is estimated to be less than 25 feet.

Green River formation	Feet
1. Limestone, 5YR 8/1 pinkish gray, fine-grained, pinhole sized vugs, many filled with calcite, bedded, alternating ledges approximately 1 foot thick and slopes.........	13
2. Shale, grey, no exposures, slope-forming, calcareous.....................................	42
3. Limestone, 5YR 8/1 pinkish gray, fine-grained, very vuggy, most filled with calcite......................................	2
4. Shale, grey, no good exposures, calcareous....	25
5. Limestone and shale interbedded, limestones are shalely, thin-bedded, have characteristic ring when struck, less mud near top of unit...	40
6. Limestone, 5YR 8/1 pinkish grey, medium-grained, slabby-bedded, cliff-forming.........	20
7. Limestone and shale interbedded, 5Y 8/4 greyish yellow, slope-forming, no outcrop.....	40
8. Tuff, 10YR 8/6 pale yellowish orange, micaseous, cliff-forming........................	4
9. Limestone, 5YR 8/1 pinkish grey, medium-grained, shalely, contains much opal..........	30
Total Green River formation exposed...........	196

Distribution and Thickness.--In the type area of western Colorado, southwest Wyoming and eastern Utah, the Green River formation covers 50,000 square miles and reaches a thickness of 2,000 feet (Moore, 1933). In central Utah the Green River formation occurs mainly in the Uinta Basin. The best exposures of the formation occur mainly at the base of the Wasatch Plateau on the north and west sides and in the upper part of the Gunnison Plateau. The Green River formation forms hogbacks along the western base of the Wasatch monocline between the head of San Pete Valley and Manti. South of Sixmile Canyon the formation forms the outer flank of the monocline (Spieker, 1949). In central Utah the Green River formation varies in thickness from 200 to 800 feet and reaches a probable thickness of 6,000 feet north of the Wasatch Plateau.

Fossils.--No fossils were found in the Green River formation in the Manti area. Fossils have been found in the formation in other areas though, and the well preserved fossils of fish are very well known. In the Ninemile Canyon Area south of Manti, fish scales and fish bones have been found in the Green River formation.

Age and Origin.--The age of the Green River formation is thought to be middle Tertiary, Eocene (Spieker, 1935). The sediments were deposited in a large freshwater lake. Oolitic limestone formed in the lake by the secretion of calcium carbonate around fine particles of shell material. As the shoreline transgressed inland the oolitic limestone was covered by a layer of mud which formed a shale bed. When the shoreline regressed the oolitic limestone again formed covering the layer of shale. By the repetition of this process the limestone, shale, limestone sequence was formed.

There are several volcanic areas in central Utah. One of these extends into the foothill belt of the Wasatch Plateau. The age of the volcanic activity is guessed to be middle

Tertiary, the same age as the Green River formation (Spieker, 1935). This volcanic activity, therefore, is a very probable source of the volcanic tuffs found in the Green River formation.

In different parts of the Green River formation there is found algae, snails, fish, fish scales and oil shale. This evidence indicates a warm climate during the time of the deposition of the formation, and an abundance of plant and animal life.

STRUCTURE

General

San Pete Valley and the Manti Area are located in a transition zone between two very different structural and physiographic provinces. To the east of this area lies the Colorado Plateau and to the west the Great Basin. On the Colorado Plateau side the rocks are nearly flat lying and simple in structure. In the Manti Area these flat lying rocks are cut by a series of normal faults and are bent downward in a monoclinal fold that is the first of the displacements bordering the Great Basin to the west (Spieker, 1931). This downward displacement of rocks toward the west has formed the Sanpete Valley. The detailed geology of the Valley beneath the alluvium, which attains a thickness of several hundred feet, is not well known. Study of the surrounding geology proves it to be structural in origin rather than erosional (Washburn, 1948).

Wasatch Monocline

The Wasatch Monocline forms the western front of the Wasatch Plateau between the town of Milburn, which is 5 miles north of Fairview, and Salina Canyon. This is a distance of approximately 55 miles (Spieker, 1949). South of Salina Canyon the monocline is not a prominent feature. The total vertical displacement between the flat lying rocks which cap the plateau to where the monocline passes under the alluvium of the valley is on the order of 6,000 to 7,000 feet. A maximum displacement of 8,500 feet is reached north of Ephraim. In general the monocline strikes N 20° - 30° east and the dips on the outer face vary between 25° and 45° to the west. This outer flank is mainly made up of the resistant beds of the Flagstaff limestone, but in the southern part of the monocline it is also composed of Green River formation (Spieker, 1949). The textbook profile of the monocline is interrupted in its eastern section by faulting and erosion. At the toe, the monocline does not flatten out gently but forms the complicated structure beneath the valley. Along the shoulder of the monocline and striking slightly more to the north is a system of antithetic faults which extend the whole length of the structure.

Grabens

Just east of these major north-south trending faults in the plateau is a group of major grabens. The most westerly and the smallest in displacement occurs at the shoulder of the monocline and is known as the shoulder graben. There are 5 major grabens besides this one and they all trend relatively north-south. They are arranged in an en echelon pattern and from northeast to southwest are called the Pleasant Valley graben, Joe's Valley graben, Musinia graben and the Water Hollow graben. Northwest of the Pleasant Valley graben is the Soldier graben.

Attitude of the Rocks

The rocks capping the Wasatch Plateau are flat to very nearly flat lying. The fault blocks between the plateau and the monocline have dips between 10° and 25°. On the monocline itself, the beds dip from 12° W on the east edge to as much as 58° W near its base. Thus the transition from the flat lying rocks of the plateau to the steep westward dips near the base of the monocline has been accomplished by faulting and tilting as well as by down warping of the rocks.

Gravity Faults

There are 5 major gravity faults which cut the plateau in the Manti area (see Map 1, and Cross Section). The faults are all normal, steeply dipping and trend northeast parallel to the monocline. These faults are a prominent feature between Manti and Willow Creek Canyons, but extend farther in both directions. The faults have been traced from Long Canyon on the south to the rim of Round Valley to the north. The easternmost of the 5 faults is the eastern fault of the shoulder graben and is downthrown on the western side. This fault marks the boundary between the monocline to the west and the Wasatch Plateau to the east. The throw on this fault is approximately 750 feet. The other 4 major faults are all downthrown to the east and do not have as great a displacement as the easternmost fault. The throw on these 4 faults diminishes from approximately 650 feet on the western fault of the shoulder graben to approximately 65 feet on the western most fault (Washburn, 1948). The faults are difficult to trace across Manti and Willow Creeks Canyons because of extensive debris flows and gravel deposits in the valleys.

There are two high-angle gravity faults on Temple Hill (Map 1). The fault on the north part of Temple Hill cuts a thrust fault and separates Green River formation in place from thrusted Green River formation. The other gravity fault is located on the west side of Temple Hill and it cuts the thrusted Green River and Crazy Hollow formations. Both of these faults have only a small throw and neither is traceable for a very long distance.

Reverse Faults

At the mouth of Manti Canyon there are two reverse faults, both dipping steeply to the east. The smaller fault is older and is traceable only in the Flagstaff limestone. Below the Flagstaff it is covered by North Horn and Flagstaff talus. The upper end of the fault has been cut off by a thrust sheet of Flagstaff limestone. The larger reverse fault cuts this thrust. The fault can be traced downward to Manti Canyon road where it becomes covered. The top of the fault has been terminated by a westward thrust of Flagstaff limestone (Map 2, and Figure 5). The fault cuts through the North Horn, Flagstaff and Colton formations. The total movement is greater than the thickness of the Flagstaff formation in this area because in one section of the fault, North Horn formation lies against Colton formation. The fault cannot be traced far because to the north it is covered by a thrust sheet and to the south it is covered by alluvium and stream gravels.

Thrust Faults

Two of the thrust faults are referred to in the preceeding section on reverse faults. Both of these faults are small in extent and are referred to by Spieker as landslide thrust faults. Beneath the upper thrust sheet of Flagstaff limestone, at the mouth of Manti Canyon, beds of the Colton formation have been dragged westward to a vertical position and have been overturned to the east in some areas (Figure 5). The thrust sheet is not large and is probably only a remnant of the original sheet. The sheet measures approximately 300 feet from east to west and 1,500 feet from north to south. Toward the north the thrust becomes indistinguishable from the Flagstaff beds in place. The thrust sheet has been folded into a synclinal structure with the axis trending north-south. The west limb of the fold dips 32 degrees east and the eastern limb dips 36 degrees to the west. Another thrust is located at Temple Hill. This is a thrust of Green River and Crazy Hollow formations over Green River and older formations with a fault plane dipping approximately 25 degrees toward the east. The trace of the thrust is lost at both the north and south ends of Temple Hill where it becomes covered by valley alluvium. The thrust sheet has been protected by the resistant Crazy Hollow formation which caps it but was probably much more extensive at the time it was thrusted. The relationship between the Green River formation in the thrust sheet and the Green River formation at the toe of the monocline is uncertain but they may be continuous.

Folds

Besides the synclinal fold previously described in the thrust sheet at the mouth of Manti Canyon, the only other major fold is another synclinal fold which is formed in the thrust sheet at Temple Hill. The axis of the syncline trends north-south and the syncline is capped by beds of Crazy Hollow formation. The west limb dips 12 degrees to the east and the east limb dips 11 degrees to the west. The fold was formed at the time the beds were thrusted from the east.

GEOMORPHOLOGY

Sanpete Valley

The Sanpete Valley is structural in origin and was not cut by the San Pitch River which flows in it. However, the river, which flows from north to south, has cut into the valley floor to a small extent, leaving some small hills of bedrock and gravel. The San Pitch River was a more effective geologic agent before it was dammed to form the Gunnison Reservoir southwest of Manti, and much of its water was removed for purposes of irrigation. The Sanpete Valley is two miles wide at Fairview. It attains its greatest width of 14 miles just 5 miles south of Fairview at Mount Pleasant. From here it narrows gradually to a width of 3 miles just south of Manti in the vicinity of the Gunnison Reservoir. The valley floor which is at an elevation of approximately 5400-5600 feet is flat and relatively unobstructed. The San Pitch River and smaller tributary streams, most of which are intermittant, have deposited a layer of alluvium in the valley which reaches a thickness of several hundred feet. All of the canyons adjacent to Sanpete Valley have fan deposits at their mouths.

Manti Area

A fan of textbook shape is present at the mouth of Willow Creek Canyon. The fan is quite large, covering an area of .7 of a square mile. Where the fan is dissected by Willow Creek, the size of the material composing the fan can be seen. Stones were not measured for ranges in size but pebbles as large as 1 inch in diameter are present near the farthest extent of the fan. The fan appears to have moved with a matrix of mud, with other material ranging up to several inches in diameter. The fan is covered with sagebrush and does not appear to have been covered by a fresh flow in many years. The sagebrush growing on the fan accentuates its shape since the surrounding land has been cleared for farming.

Manti Canyon.--Much mass movement has taken place in Manti Canyon. About two miles east of the mouth of the canyon a large debris flow has moved north from the south wall of the canyon into Manti Creek. This has forced Manti Creek to flow in a more northerly course. This flow was studied by Wallace (1964) and he concluded that the material was not of glacial origin as some had formerly thought but was a slow moving debris flow. The flow is related to one of the major north-south trending antithetic faults which cut the canyon. There is a series of similar but smaller flows on the north side of the canyon. These too are related to the major faults cutting the canyon walls. It is not unusual that these flows are related to the faulting. As the winter snow accumulation melts, the more permeable fault zone offers an excellent route for the melt water. This water along with the brecciated material in the fault zone combine to produce the slow debris flows.

There is more vegetation on the south side of the canyon walls than on the north side. The vegetation retards the runoff of surface water and thus produces conditions more favorable for chemical weathering in the forms of hydrolysis, carbonation and oxidation. Mechanical weathering is aided by the action of the roots of the vegetation fracturing the bedrock. The more active forces of weathering reducing the rock particle size on the south canyon wall is the probable cause for the more extensive debris flows on this side of the canyon.

The north wall of Manti Canyon has little vegetation, and the slopes are covered extensively by talus. The talus slopes are more active as you go east in the canyon. In the area approximately 3 miles east of the canyon entrance the talus is derived for the most part from the Flagstaff limestone. The Flagstaff limestone here forms a near vertical wall approximately 300 feet high. The individual pieces of talus on the slope range from gravel size material up to blocks several feet in diameter. All the material is loose and the talus slope is active. Nearer to the entrance of the canyon the particle size of the talus diminishes and only scattered pieces of boulder size are found. The talus becomes composed more from the shale of the North Horn formation than limestone from the overlying Flagstaff. The material for the most part is not loose and is compacted to form a very hard surface. No change in the vegetation pattern can be seen on the slopes by comparing aerial photographs taken approximately 6 years apart, therefore the talus slope near the canyon entrance could be termed a fossil talus.

North of Manti Canyon and east of the plunging front of the monocline approximately two miles, the surface is nearly flat lying between Manti and Willow Creek Canyons. The elevation here is about 8,500 feet. In this area the major north-south trending faults can be traced. Fault line scarps are evident in many places. Other evidence for faulting is the occurrence in places of small ponds which have formed along fault scarps.

Wasatch Monocline.--The dominant geomorphic feature on the west flank of the monocline is a major rockslide. It is located immediately south of Willow Creek and it covers an area of approximately 1.5 square miles. The material involved in the slide is Flagstaff limestone. Many of the blocks are so large that they falsely appear at first to be exposures of bedrock. No actual exposures can be seen through the slide debris. The source area of the slide debris can easily be seen by a still visible scar on the flank of the monocline above the debris. The stripped area is a bedding plane surface of the Flagstaff limestone. The slide did not occur instantaneously as many rockslides do. If it had, the debris would have been much more broken up and would have carried much farther out into the valley. The rock moved more like a thrust sheet than a typical rock slide. Such movements have been described by Billings (1954) as collapsed structures. Just west of the slide debris there is flat lying Green River formation exposed as far west as U.S. Route 89. The only other location in the area where Green River has been preserved west of the flank of the monocline is at Temple Hill. At Temple Hill the Green River formation is protected by rock thrusted over it. West of the rockslide area, the Green River was probably protected by material of the rockslide which has since been eroded away. Much erosion of the rockslide material is evident by deep gullies which now cut it. The fresh appearance of the rockslide scar indicates a recent geologic age for the event. It could probably be best described as post-monocline but pre-historic in age.

GEOLOGIC HISTORY

Mesozoic Era

The oldest formation in the Manti area is the North Horn formation. The earliest sediments of this formation were laid down in Lance time which marked the end of the Mesozoic era and the Cretaceous period. The Colorado Plateau area at this time consisted mostly of a large coastal flood plain. The Late Cretaceous sea lay to the east of the coastal plain and a north-south trending mountain chain, the early Laramide Mountains, in western Utah was the source area for the sediments which were deposited on the flood plain and in the sea. The flood plain was partially occupied by shallow fresh-water lakes with constantly shifting shorelines. These lakes were the environment of deposition for the fine-grained sediments of the lower North Horn formation. The lakes disappeared about the end of the Cretaceous period and the depositional environment for the North Horn sediments of Paleocene age was mostly fluvatile. These fluvatile sediments were more coarse-grained than the lacustrine sediments and were deposited as alluvial fans and channel fillings in a narrow belt in the Sanpete and Sevier Valleys of Utah.

Cenozoic Era

Tertiary Period.--A period of normal faulting began in early Paleocene time, near the end of the deposition of North Horn. The evidence for this faulting, which preceeded the pre-Flagstaff monoclinal arching, is found in the Dry Canyon area on the east front of the Gunnison Plateau (Spieker, 1949). The normal faulting which began at this time, continued intermittantly through the Pleistocene Epoch.

During the middle Paleocene, before the deposition of the Flagstaff limestone, there was a period of arching which produced an east facing monocline in the Sixmile Canyon area. The arching did not effect the beds in the Manti area which is immediately north of Six Mile canyon.

In the late Paleocene epoch the central Utah area was invaded by a large fresh-water lake. This shallow and calm lake was produced by crustal subsidence which was more pronounced toward the east. Arms of the lake spread toward the east in basins between the Circle Cliffs, Kaibab and San Rafael upwarps (Hunt, 1956). The Flagstaff limestone was deposited in the lake. Near the end of the period of deposition of the Flagstaff, volcanic ash with a probable ryholitic composition was deposited in the lake. During some part of the Flagstaff deposition, there was an enclosed basin in the central part of the Wasatch Plateau which contained saline water from which gypsum was deposited (Spieker, 1946).

In early Eocene time the Flagstaff lake receeded toward the west. Floodplain sediments, variegated sandstones and shales, were introduced from the east. They covered most of central Utah and displaced the Flagstaff lake. Because of the irregular retreat of the lake, the floodplain and lake sediments intertongued forming the fresh-water Colton formation.

This formation lies conformably above the Flagstaff limestone in the Manti area.

Immediately following the deposition of the Colton formation a period of normal faulting took place. The evidence for this faulting is on the west slope of the Gunnison Plateau (Spieker, 1949).

In middle Eocene time, downwarping of the Colorado Plateau commenced and spread eastward. Into this basin spread the Green River lake which at its greatest extent covered the eastern two thirds of Utah, western Colorado and southern Wyoming. The eastern shore of the lake was against the western foot of the Rocky Mountains in Colorado (Hunt, 1956). This fresh-water lake was large and shallow. The sediments which were deposited into the lake to form the Green River formation were carbonaceous, calcareous and intermittantly volcanic. This reflects a warm, humid climate with some volcanism taking place. The Green River lake was gone by the end of middle Eocene time. Its dissappearance was perhaps due partly to uplift and partly to filling in of the basin with sediments (Hunt, 1956). After the deposition of the Green River formation, and before the Crazy Hollow formation began to be deposited there was a period of normal faulting. The evidence for this faulting is in the Salina district (Spieker, 1949).

After the deposition of the Green River formation there is an erosional break of regional extent. This is the first extensive break in the record since the base of the Price River formation, and the only break in the record in the Manti area.

In late Eocene time there was renewed uplifting of the San Rafael Swell in central Utah and the Uinta mountains of northern Utah. This was followed by the deposition of thousands of feet of fluviatile sandstones and conglomerates. A part of these clastic sediments is represented by the Crazy Hollow formation which was deposited disconformably on the Green River erosion surface in late Eocene time. Following the deposition of the Crazy Hollow formation, the structures of the Wasatch Monocline began to form, also in late Eocene time. The monocline and related structures were formed by forces of uplift rather than compression (Figure 2). The magnitude of the uplift varied in intensity from west to east. The forces of uplift underlying Sanpete Valley were weak relative to the forces farther east and therefore lies at a much lower elevation than the plateau. The stronger uplift east of the valley bent the strata into the monoclinal structure. The stress applied on the strata at the toe of the monocline caused reverse faulting. Two reverse faults are visible at the mouth of Manti Canyon (Map 2). The strength of the uplift becomes more uniform east of the monocline and the uplifted rocks form the relatively flat lying Wasatch Plateau. The uplift produced much tension in the brittle surface strata of the plateau causing the rocks to fracture in a series of normal antithetic faults which trend north-south (Map 1). The tension also produced the shoulder graben whose western wall was produced by the eastern most major antithetic fault. Occurring contemporaneously with the high-angle faulting and continuing into the early and middle Oligocene was a period of thrusting. Some small scale thrusts alternated with the reverse faulting at the mouth of Manti Canyon (Map 2). The sequence of events in this area is: (1) Small reverse fault in Flagstaff limestone. (2) Thrusting of lower Flagstaff, cutting the small reverse fault. (3) The larger reverse fault which cuts the thrust. (4) Thrusting of upper Flagstaff which cuts the large reverse fault. A larger thrust with Green River and younger strata being thrust over Green River formation, occurred at Temple Hill (Map 1 and Cross Section). Thrusting in the Central Utah area continued intermittantly until the end of the Tertiary Period.

Quaternary Period.--During Pleistocene time there has been renewed movement on some of the normal faults in the region. On the top of the Wasatch Plateau near the main divide is the only place where this late faulting can be clearly demonstrated (Spieker, 1949).

During the Pleistocene but pre-history in age, the rock-sliding on the dip slope of the monocline occurred. To a large extent the beds have moved downslope as a unit, folding in some areas (Such movements are described by Billings as collapsed structures caused by gravity sliding.)

More recent but still pre-history in age is the formation of the boulder fan at the mouth of Willow-Creek Canyon. Still more recent are the flows of debris associated with the high-angle faults in Manti Canyon and the formation of the gravel terraces in Manti Canyon. Sanpete Valley has been filling with alluvium since the uplift of the monocline in late

Eocene time until the present.

The Central Utah area is still active geologically. There has been movement on fault planes within the last 46 years. During an earthquake in 1921, a fault scarp 50 feet in height was formed on the west side of Round Valley which lies on the west edge of the Valley Mountains. Round Valley is a graben which has a throw of approximately 5,500 feet. Besides such large scale changes which occur intermittantly, at the present time the more subtle forces of chemical and mechanical weathering and downslope movement are continually at work changing the aspect of the landscape.

ECONOMIC GEOLOGY

Limestone

Northeast of Manti, at Temple Hill, limestone has been quarried as a building stone. The stone was quarried from the upper Green River formation and is a yellow, oolitic limestone. This stone was used in the construction of the Mormon Temple at Temple Hill and several other buildings in the Manti area.

Gravel

There is a gravel quarry located on the north side of Manti Canyon road just west of the canyon entrance. This is the only active quarry in the Manti area. Some gravel has been removed from the north side of Manti Canyon road just east of the entrance of Manti-La Sal National Forest. Much gravel is available along both Manti and Willow Creeks but in general the gravel is too coarse to be used without crushing.

Water

Water is obtained both from surface runoff and from wells. Wells which are drilled into gravel deposits beneath the valley alluvium are deep and do not yield large quantities of water. Therefore the major source of water is stream runoff of melting snow high in the plateau. The two major uses of the water is for irragation and the generation of electricity. The town of Manti has two hydroelectric generating stations on Manti Creek. One is located at the mouth of Manti Canyon on the north side of Manti Creek. The other station, which is smaller, is located 1.8 miles east of the larger station and is also on the north side of the creek.

Water for irragation is obtained from both Manti and Willow Creek. The water is distributed by a large network of ditches. Most of the ditches are earthen ditches dug in the ground but many of the larger ones are constructed of concrete and are permenant structures. In late summer when the stream flow is low, the streams are supplemented by water stored in three small reservoirs in Manti Canyon.

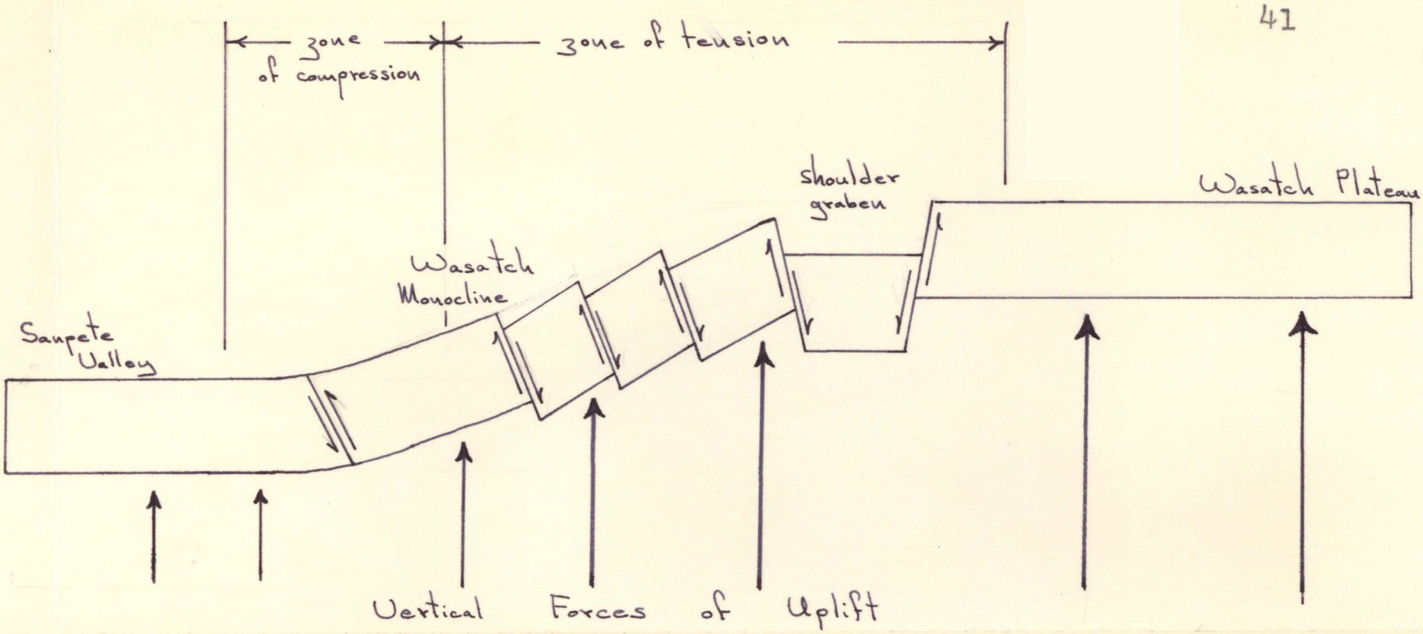

Figure 2.---Diagram showing the direction and magnitude of the forces which formed the Wasatch Monocline. (The length of the arrow indicates the relative magnitude of the force.)

Figure 3.---Aerial view of the Wasatch Monocline and Manti Canyon 1/2 mile north of the mouth of the canyon.

Figure 4.---The north wall of Manti Canyon viewed toward the northeast from near the mouth of the canyon.

Figure 5.---Beds of Flagstaff limestone thrusted toward the west over beds of the Colton formation producing drag and overturned beds. View is toward the north from the road at the mouth of Manti Canyon.

Figure 6.---View of the north wall of Willow Creek Canyon, looking north from the south wall.

Figure 7.---View of the monocline between Willow Creek Canyon and Manti, looking south from the north wall of Willow Creek Canyon.

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